Instabilities in Hybrid Liquid Crystal Optical Bistable Devices

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In this paper we report some of the experimental results that can be obtained in the field of hybrid optical bistable devices when liquid crystals are employed as non linear materials. The advantages with respect to other materials are the very low voltages and power needed, compatibles with I.C.'s levels.

The employed structure has been a parallel twisted nematic cell with crossed polarizers placed on its faces. We have used nematics of positive types but some results can be obtained with negative too.

The experimental set-up is essentially similar to the one used previously for mirrorless bistable optical devices and presented by us. The output power from the system is sampled by a beam splitter and a phototransistor. After amplification the signal is fed back to the electrodes of the nematic cell (Fig. 1).

The main point with respect to this arrangement is the nematic liquid crystal structure position with respect to the optical beam.

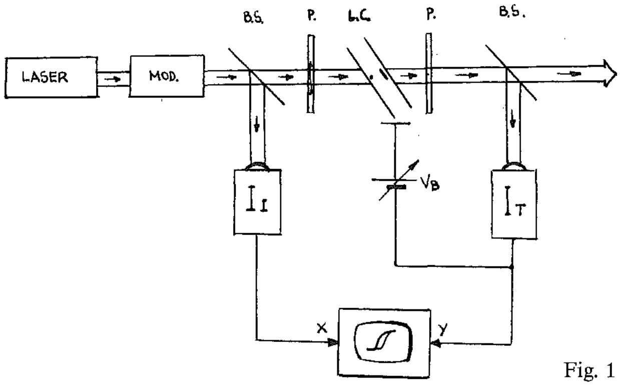

Fig. 1

Because the transmission vs voltage characteristics of such a cells with respect to the input beam, optical bistability can be obtained for an small range of angles. In our case for angles between 40° and 45°, and a clockwise turn of the liquid crystal molecules from the frontal surface to the exit surface, optical bistability was obtained. The effects of optical input power and feedback gain have been studied.

Biasing voltages between 0 and 2 V give rise to hysteris cycles. Some results are obtained for voltages higher than 2.5 V. But between 2 and 2.5 V many other results have been obtained. For some feedback gain optical bistability is obtained. This bistability was for input triangular light signals up to frequencies near 100 Hz. In these cases, rise times were smaller than 0.1 ms. Optical clipping was obtained too.

For pulsed light signals, two types of oscillation were obtained, with 2.1 V as bias voltage and a certain level of feedback gain. An smaller frequency, around 20 Hz was obtained for low feedback. Higher feedback gives an oscillation frequency of 130 Hz. Under some conditions both oscillations were obtained together, either showing a quasi-chaos, when both of them are superposed, or oscillating from one to another. This behaviour was obtained too when the output polarizer was forming an angle smaller than 90° with respect to the input one. This behaviour comes from the new transmission characteristic for the nematic cell. Different frequencies can be obtained for different cell angles.

For sufficiently long input pulses, alternate switching has been obtained. In this case, as it have been show with some other materials, four distinct modes of transmission can be obtained. Overshoot switching appears for some values of the electronic feedback.

In the reported device, the behaviour is mainly dependent on the two constant times had by the two final orientation of the nematic molecules: When they are parallel to the surfaces and when they are perpendicular. Several other situations can be obtained for intermediate orientations. We have employed MBBA+PEBAB as liquid crystals and a 5 mW. He–Ne laser as input light, with several light modulators.